Neutral Shallow Acceptors in Heavily Doped Bulk CdTe at Room Temperature

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Room temperature photoluminescence has been observed near the band gap of doped CdTe for three decades. Jaesun Lee *et al.* assigned the luminescence peak to free exciton and free carrier recombination [1]. We propose a new model of (e,A^0) transition for this band gap luminescence. Possibility of luminescence related with shallow impurities has been excluded because of their thermal ionization at room temperature while we notice that some amount of the shallow impurities remain neutral in heavily doped semiconductors even at room temperature [2].

The bulk CdTe samples were grown by liquinert-processed vertical Bridgman method with use of $SiCl_4$ to escape wetting the surface of a crucible [3]. The samples are semi-insulating because intrinsic Cd vacancies are compensated by Cl donors. One of them was excited by a semiconductor laser with the wavelength of 447nm and the power of 50 mW. The luminescence was detected by a 10 cm monochromator with a CCD . The photoluminescence peak is asymmetric with a broad high energy tail which is typical of (e,A^0) luminescence as shown in Fig.1. The lineshape was fitted by product of the density of states and Boltzmann factor. The higher energy side is fitted very well while the lower energy side is difficult to fit. We include the broadening due to the scattering of the conduction electrons by Lorentzian function with the broadening factor Γ. The fitted result is shown in Fig.1 and it is estimated that the ionization energy of the acceptor is 25 meV and the broadening factor Γ is 9 meV. We speculate that the shallow acceptor is the complex of a Cd vacancy and a Cl donor.

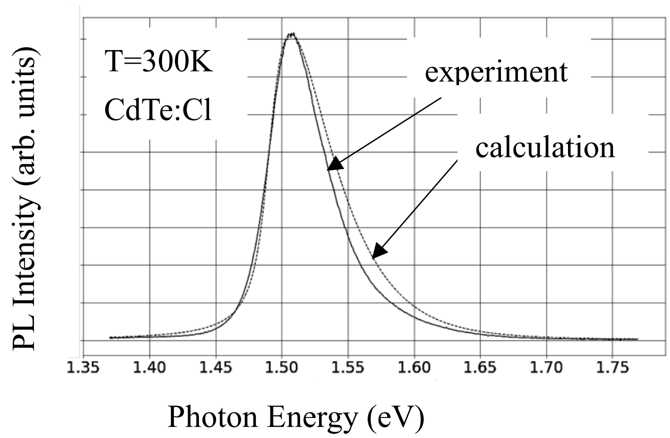

Fig.1 Photoluminescence spectrum of CdTe:Cl

The ionization energy is comparable to the thermal energy of 300K. It is believed that such an acceptor should be ionized at room temperature. We consider that remarkable amount of shallow impurities keeps neutral even at room temperature when the concentrations of impurities are rather high. We calculated the density of the residual neutral acceptors in highly doped semiconductors. As a result 10^{15} cm^{-3} acceptors remain neutral in the sample with the acceptor concentrations of 10^{17} cm^{-3} . It means that observable amount of acceptors keeps neutral for the semiconductor with heavily doped acceptors.

The main origin of the broadening at lower energy side is electron-polar optical phonon scattering. We calculated the DC mobility and estimated the broadening factor Γ of 12 meV which is almost the same as the observed one. The half width at the lower energy side at 300K is five times as large as that at 10K. This temperature dependence can be explained by the factor of $\sqrt{T}$ in the broadening parameter Γ due to electron-phonon scattering.

References

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